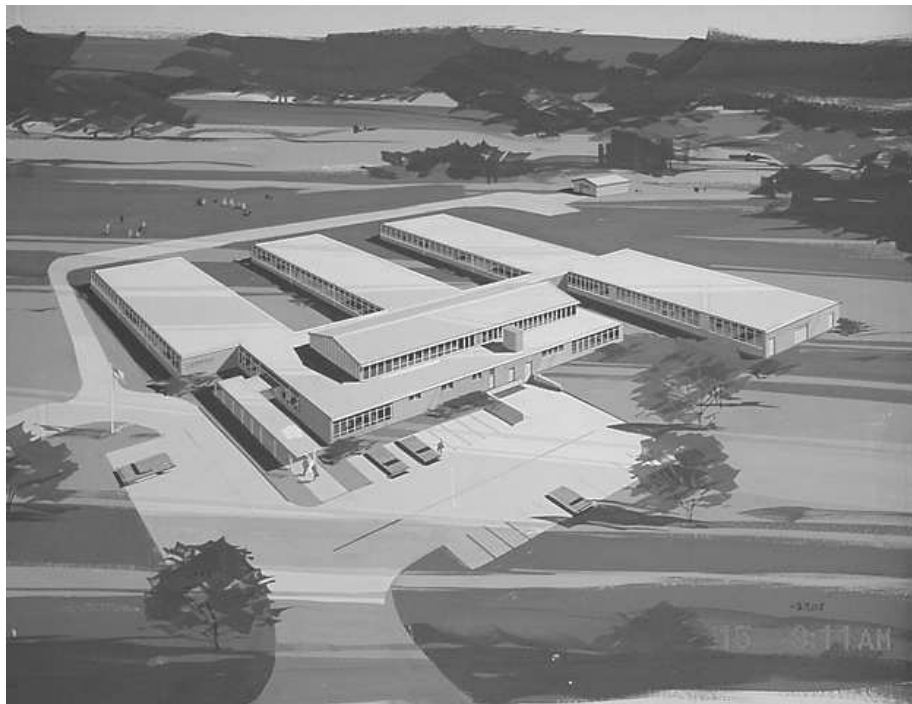


INDOOR AIR QUALITY ASSESSMENT

**L.G. Nourse Elementary School
38 Plain Street
Norton, MA 02766**



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
October 2004

Background/Introduction

At the request of parents, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Nourse Elementary School (NES), 38 Plain Street, Norton, Massachusetts. The IAQ assessment was prompted by indoor air quality concerns stemming from a roof replacement project. On April 15, 2004, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program.

The NES is a multi-winged, one-story brick building constructed in 1960. An addition was built in 1962. The school contains general classrooms, art room, gymnasium, cafeteria, library, specialty rooms and office space. Windows are openable throughout the building.

According to school officials, the roof replacement project began in early April 2004 and was scheduled for completion over April vacation (April 17-25). The BEHA assessment occurred two days prior to April vacation. At the time of assessment, the roof replacement was nearly complete and work to complete the project appeared to be minimal.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particulate matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds was conducted

using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The NES houses approximately 480 pre-kindergarten through third grade students and a staff of approximately 75. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million of air (ppm) in fifteen of twenty-eight areas surveyed, indicating inadequate ventilation in a number of areas. It is also important to note that several of the rooms with carbon dioxide levels below 800 ppm were unoccupied or sparsely populated, which can greatly reduce carbon dioxide levels.

Fresh air is supplied to classrooms by a unit ventilator (univent) system (Picture 1). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and returns air through an air intake located at the base of the unit ([Figure 1](#)). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents are equipped with control settings of low, medium or high (Picture 3). The majority of univents were operating during the assessment; however, some univents had been deactivated by occupants. In order for univents to provide

fresh air as designed, these units must remain “on” and allowed to operate while rooms are occupied.

Mechanical exhaust ventilation is powered by rooftop fans. Exhaust vent grilles are located in the ceilings of coat closets (Picture 4). Air is drawn into the classroom coat closet via undercut closet doors (Picture 5). The exhaust system was either not functioning or drawing weakly in several areas surveyed, indicating that motors were deactivated or non-functional (Table 1). The location of these closet vents also allows them to be easily blocked by stored materials (Picture 6). In classrooms 16 and 31, the undercut closet doors were blocked by a curtain and furniture, respectively (Pictures 7 and 8). As mentioned, such blockages restrict airflow. As with the univents, exhaust vents must be activated and remain free of obstructions in order to function as designed. Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality complaints.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that a room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide, see [Appendix A](#).

Temperature readings ranged from 71 ° F to 74 ° F, which were within the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents and exhaust vents deactivated/obstructed).

Relative humidity measurements ranged from 31 to 46 percent, which were below the BEHA comfort range in some areas. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be

expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

BEHA staff examined the building exterior and observed several downspouts missing from the drainage/gutter system (Picture 9). Sections of the exterior walls appeared to be saturated with moisture and moss growth (Pictures 9 and 10). Moss growth on exterior brickwork is an indication of chronic moisture exposure from rainwater. Moss growth holds moisture against brickwork. Excessive exposure of exterior brickwork to water can result in damage over time. Mortar around exterior brickwork appeared to be crumbling or missing in some areas (Picture 11). During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork. Damaged brickwork can become a point of water intrusion.

Plants were observed in several classrooms. Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne

particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM_{2.5}) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM_{2.5}.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

As previously discussed, the US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM₁₀). According to the NAAQS, PM₁₀ levels should not exceed 150 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM_{2.5} standard requires outdoor air particulate levels be maintained below 65 $\mu\text{g}/\text{m}^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM₁₀ standard for evaluating air quality, BEHA uses the more protective proposed PM_{2.5} standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM_{2.5} concentrations the day of the assessment were measured at 8 $\mu\text{g}/\text{m}^3$. PM_{2.5} levels measured indoors ranged from 7 to 26 $\mu\text{g}/\text{m}^3$ (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system; cooking in the cafeteria stoves

and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were non-detect (ND). Indoor TVOC measurements throughout the building were also ND (Table 1). Please note that TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While TVOC levels were ND, materials containing VOCs were observed in the school.

Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were found on countertops and beneath sinks in a few classrooms. Cleaning products contain VOCs and other chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

Several other conditions that can affect indoor air quality were noted during the assessment. In several classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for

dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Lastly, an unvented pottery kiln is located in classroom 31 (Picture 12). No mechanical local exhaust ventilation exists for the kiln. Kiln exhaust may produce corrosive, hazardous and irritating materials, including chlorine, sulfur dioxide and carbon monoxide. Pottery kilns should be provided with dedicated local exhaust ventilation (McCann, 1985) to ventilate these possible emissions from the interior of the building.

Conclusions/Recommendations

As discussed, at the time of the BEHA assessment, the roof project was nearing completion and work being conducted was minimal. However, several other issues that can negatively affect indoor air quality were identified. Considering the concerns prompting the visit and the problems identified, the BEHA provides two sets of recommendations: specific indoor air quality recommendations based on this assessment and recommendations to prevent construction/renovation-generated pollutants from migrating into occupied areas of the building for any future renovation projects. Renovation recommendations are provided in the event construction/renovation activities are conducted in the future.

Specific Indoor Air Quality Recommendations

1. Ensure all operable ventilation systems (supply and exhaust) throughout the building (e.g., classrooms, gym, auditorium) are operating continuously during periods of school occupancy.

2. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Consult a ventilation engineer concerning re-balancing of the ventilation systems.
Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
5. Clean/change filters for air handling equipment as per manufacturer's instructions or more frequently if necessary.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Reconnect downspouts to the gutter system to direct rainwater away from the building.
8. Re-point exterior brickwork in areas with missing/damaged mortar.
9. Ensure plants are equipped with drip pans. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
10. Consider discontinuing use of the pottery kiln until local exhaust ventilation is provided.
11. Store cleaning products properly and out of reach of students.

12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
13. Consider adopting the US EPA (2000b) document, Tools for Schools, to provide self-assessment and maintain a good indoor air quality environment at your building. The document can be downloaded at <http://www.epa.gov/iaq/schools/index.html>.
14. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at <http://www.state.ma.us/dph/beha/iaq/iaqhome.htm>.

As discussed, the following recommendations should be implemented in the event of future renovation projects to reduce the migration of renovation-generated pollutants into occupied areas. We suggest that these steps be taken on any renovation project within a public building.

Construction/Renovations:

1. Comply with 603 CMR 38.00: School Construction – Massachusetts Department of Education. This regulation states that “[a]pplicants shall implement containment procedures for dusts, gases, fumes, and other pollutants created during renovations/construction as part of any planned construction, addition to, or renovation of a school if the building is occupied by students, teachers or school department staff while such renovation and construction is occurring. Such containment procedures shall be consistent with the most current edition of the IAQ Guidelines for Occupied Buildings

Under Construction published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA). All bids received for school construction or renovations shall include the cost of planning and execution of containment of construction/renovation pollutants consistent with the SMACNA guidelines [608 CMR 38.03(13)] General Requirements: Capital Construction” (MDOE, 1999).

2. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
3. Schedule projects that produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
4. Cover dirt/debris piles with tarps or wet down to decrease aerosolization of particulates, when possible.
5. Ensure faculty is aware of construction activities that may be conducted in close proximity to their classrooms. In certain cases, classrooms adjacent to construction activities may need to have their HVAC equipment deactivated and windows closed periodically to prevent unfiltered air and vehicle exhaust from entering the building. For this reason, prior notification(s) should be made.
6. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.
7. Monitor Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).

Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.

8. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the *re-entrainment* of these materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).
9. Relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas under renovations, if possible.
10. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. Consider increasing the number of full-time equivalents or work hours for existing staff (e.g., before school) to accommodate increase in dirt, dust accumulation due to construction/renovation activities. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner in conjunction with wet wiping/mopping of all surfaces is recommended.
11. Consider changing HVAC filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring filters that are more efficient for these units.

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Picture 1



Typical Classroom Univent

Picture 2



Univent Fresh Air Intake

Picture 3



Univent Manual Controls

Picture 4



Classroom Exhaust Vent in Top of Coat Closet

Picture 5



Undercut Coat Closet Doors for Exhaust Vents

Picture 6



Materials Stored on Top Shelf Near Exhaust Vent

Picture 7



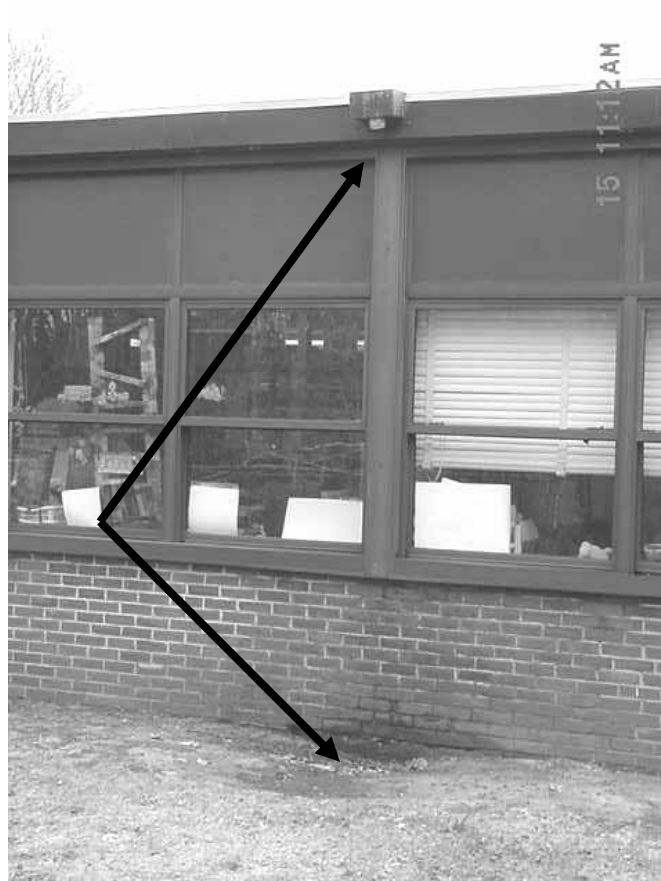
Curtain Restricting Airflow into Coat Closet Exhaust

Picture 8



Undercut Closet Doors Obstructed by Furniture

Picture 9



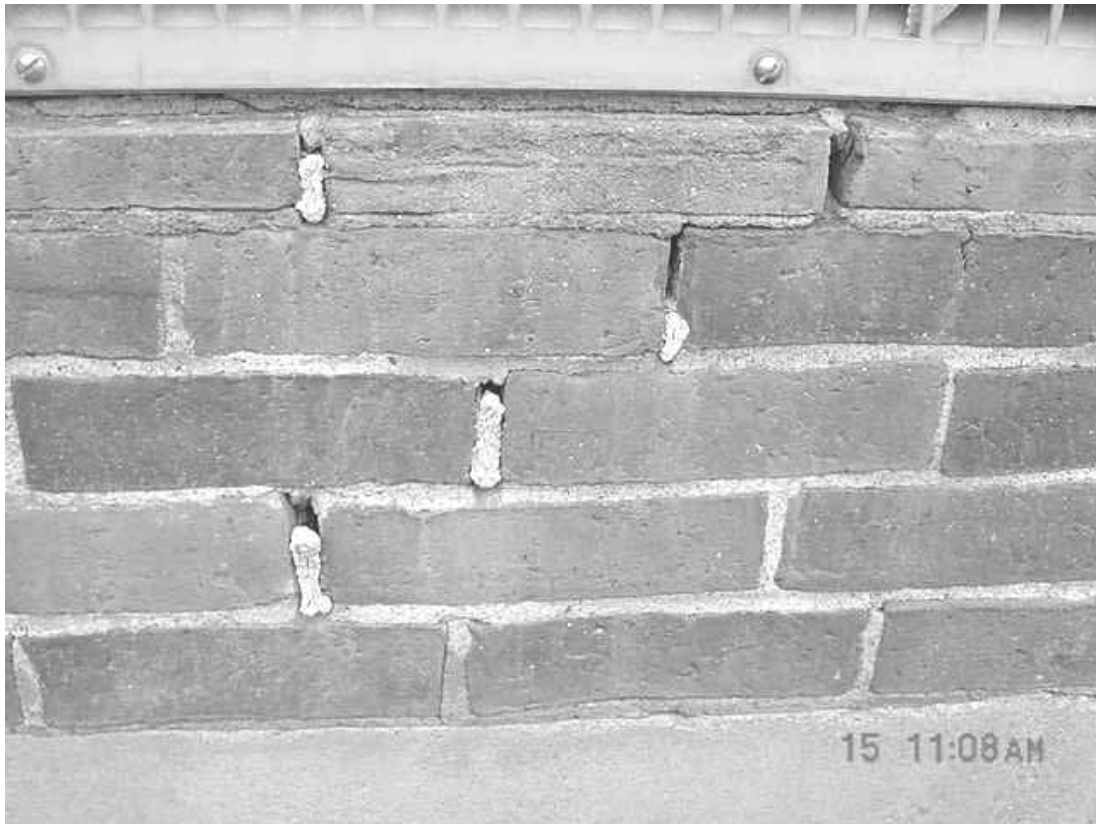
Missing Downspout, Note Trough and Staining/Moistening of Brickwork

Picture 10



Close-Up of Moss on Exterior Brickwork

Picture 11



Missing/Damaged Mortar beneath Univent Air Intake

Picture 12



Unvented Pottery Kiln

L. G. Nourse Elementary School
38 Plain Street, Norton, MA 02766

Indoor Air Results
April 15, 2004

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (Outdoors)	46	49	363	ND	ND	8	-	-	-	-	Cloudy, intermittent rain, North winds 15-20 mph
Gym	73	38	832	ND	ND	14	1	Y	Y	Y Wall	Hallway door open
Cafeteria	71	31	636	ND	ND	10	~100	Y	Y Wall	Y Wall	Hallway door open
Main Office	71	36	708	ND	ND	11	2		Y Ceiling	Y Ceiling	Hallway door open
11	71	33	616	ND	ND	21	7	Y	Y Univent	Y Closet	Hallway door open
12	72	34	595	ND	ND	8	16	Y	Y Univent	Y Closet	Hallway door open
13	71	37	600	ND	ND	8	14	Y	Y Univent	Y Off Closet	Hallway door open
15 Library	71	31	437	ND	ND	10	0	Y	Y Univent	Y Ceiling	Hallway door open

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Table 1-1

L. G. Nourse Elementary School
38 Plain Street, Norton, MA 02766

Table 1

Indoor Air Results
April 15, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
16	71	35	552	ND	ND	7	0	Y	Y Univent	Y Closet	Hallway door open; exhaust blocked by curtain
21	72	37	1005	ND	ND	12	20	Y	Y Univent		DEM
22	71	36	774	ND	ND	11	0	Y	Y Univent	Y Off	DEM
23	72	40	1529	ND	ND	26	22	Y	Y Univent		DEM, plants; hallway door open
24	74	36	928	NDD	ND	14	21	Y	Y Univent	Y Off Closet	DEM; hallway door open
25	72	42	1634	ND	ND	20	23	Y	Y Off Univent	Y Off Closet	DEM; hallway door open
26	73	36	953	ND	ND	13	233	Y	Y Univent	Y Closet	DEM; hallway door open
31	72	37	898	ND	ND	21	18	Y	Y Univent	Y Closet	Hallway door open; Kiln unvented inside classroom; exhaust blocked by furniture

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Indoor Air Results
April 15, 2004

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
32	72	36	720	ND	ND	14	13	Y	Y Univent	Y Off	DEM
33	74	38	1203	ND	ND	10	21	Y	Y Univent	Y Off Closet	DEM
34	72	37	780	ND	ND	15	3	Y	Y Univent	Y Off Closet	DEM
35	72	35	627	ND	ND	11	2	Y	Y Univent	Y Closet	17 occupants gone ~ 40 min
36	72	35	893	ND	ND	11	18	Y	Y Univent	Y Off Closet	Plants; hallway door open
41	74	33	636	ND	ND	12	5	Y	Y Univent	Y Closet	DEM
42	74	35	685	ND	ND	10	9	Y	Y Univent	Y Closet	DEM; hallway door open
43	72	42	903	ND	ND	15	20	Y	Y Univent	Y Closet	DEM; hallway door open

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Table 1-3

L. G. Nourse Elementary School
38 Plain Street, Norton, MA 02766

Indoor Air Results
April 15, 2004

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
44	72	42	1002	ND	ND	15	23	Y	Y Univent	Y Closet	DEM, cleaners; hallway door open
45	74	35	856	ND	ND	12	3	Y	Y Univent	Y Closet	DEM, cleaners; hallway door open
46	73	39	970	ND	ND	12	18	Y	Y Univent	Y Closet	DEM; hallway door open
47	71	39	982	ND	ND	15	23	Y	Y Univent	Y Closet	DEM; hallway door open
48	73	46	981	ND	ND	11	0	Y	Y Univent	Y Closet	DEM, clutter; hallway door open; ~20 occupants gone 5 min.

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µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%